Venus Sample Return Architectures: Surface Atmosphere Segment

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I. Introduction: JPL is studying options for a Venus sample return (VSR) mission for NASA's strategic plan development. The science rationale and an overview of the trade space for the entire mission are provided in a separate presentation. This presentation will focus on some new aerobot-based ascent/descent concepts that are being considered within the VSR study. These offer the potential for obtaining multiple globally-distributed samples recovered on a single Venus Ascent Vehicle (VAV), high resolution documentation of the sampling sites, and supporting in situ chemical analysis of the samples.

The return to Earth of samples of the surface of Venus presents formidable challenges. Not only does Venus have a large gravitational field, comparable to that of Earth, but it also has a high surface temperature and pressure. A rocket ascent from the surface of the planet is impractical. In 1985, R.Jones et al (1) proposed deploying a rocket ascent vehicle on a balloon in the Venus upper atmosphere and bring samples from the surface to the ascent vehicle using a second balloon and an aircraft. During the last five years JPL has examined a number of concepts for robotically controlled balloons or aerobots. The Venus Geoscience Aerobot (VGA) concept uses reversible fluid altitude control to carry out repeated descents to the surface of Venus returning to altitude to cool its electronics and sensors. The Venus Multisonde Mission (VMM) uses a constant altitude aerobot that deploys of a number of small sondes to the surface to conduct imaging and compositional measurements. The new concepts described here build on this background,

II. The Two Balloon/Airplane Architecture: The *two balloon/airplane* architecture of R.Jones et al (1) for a Venus sample return mission involves the following steps:

- Emplacement of a balloon-borne Venus Ascent Vehicle (VAV) in the upper atmosphere
- Delivery of a sample acquisition system to the Venus surface
- Acquisition of the sample and documentation of the sampling site
- Transport of the sample by a ground inflated balloon to the upper atmosphere
- Transfer of the sample from the sample balloon to the VAV balloon with an airplane
- Ascent of the VAV on either a direct Venus Earth trajectory or to Venus orbit rendezvous

This architecture involves development of both lighter than air (LTA) and heavier than air (HTA) vehicles. The complexity of having LTA vehicles rendezvous with HTA vehicles introduces high-risk into the sample transfer stage. The LTA vehicles used are simple balloons with no control capability. The aerobot architectures discussed below involve LTA vehicles that use both buoyancy control and propulsion for rendezvous with a Venus Ascent Vehicle simplifying the architecture and reducing the risk in the sample transfer phase.

III. Venus Sample Return Architectures using Aerobots. We are considering two aerobot-based architectures: in one the aerobot is similar to the Venus Geoscience Aerobot (2), which can make multiple trips from the upper atmosphere to selected surface locations using a reversible fluid buoyancy control; in the other the aerobot facilitates broad distribution of grab-sample sondes.

A. Venus Geoscience Aerobot Approach: The essential features of this approach are as follows:

- Emplacement of a blimp-borne Venus Ascent Vehicle (VAV) in the upper atmosphere. This vehicle is capable of lateral mobility of about 5 m/sec
- Emplacement of a Venus Geoscience Aerobot (VGA) equipped with a surface sampling device and an imager and other sensors for characterizing the sampling site.

- Descent by the VGA to the surface to acquire samples and returns to the upper atmosphere before its avionics overheat.
- Rendezvous of the VGA and the VAV using some combination of the buoyancy control system of the VGA and the mobility system of the VAV exploiting the pronounced vertical and small horizontal wind shear in the Venus atmosphere.
- Transfer of the sample from the VGA to the VAV
- Ascent of the VAV on either a direct Venus Earth trajectory or to Venus orbit rendezvous

B. Venus Multisonde Aerobot Approach: The essential features this approach are as follows:

- Emplacement of a *balloon-borne* Venus Ascent Vehicle (VAV) in the upper atmosphere. This vehicle requires no lateral mobility and no altitude control beyond that required for operating in a safe altitude range
- Emplacement of a Venus Multisonde Aerobot (VMA) in the upper atmosphere carrying multiple Sampling Sondes
- Sequential deployment of the Sampling Sondes to the Venus surface
- Acquisition of a sample and documentation of the sampling site
- Transport of the sonde samples by balloon to the upper atmosphere
- Retrieval of the sample from the sample balloon to the VAV balloon
- Transfer of the samples from the VMA to the VAV
- Ascent of the VAV on either a direct Venus Earth trajectory or to Venus orbit rendezvous

The elements of this architecture warrant further explanation.

1. Venus Multisonde Aerobot: The purpose of this vehicle is threefold

- to deploy the sampling sondes probes from an altitude of about 60 km to the surface
- to collect the samples when they ascend to altitude
- to transport the samples to the VAV for return to Earth; as an option VMA may carry the Earth ascent vehicle taking the functions of the VAV.

To carry out these functions the VMA must be equipped with both buoyancy control and lateral mobility.

2. Sampling Sondes: Each sampling sonde is deployed from the VMA to the surface and acquires a *grab sample* at impact. An ammonia (or water) balloon is deployed and lifts the sample back to the upper atmosphere where it can be retrieved by the VMA. . Each sampling sonde is equipped to acquire imaging and spectroscopic data during the final stages of descent to the surface and communicate that data documenting the sampling site to the carrier vehicle,

To economize on mass most of the sampling sonde would remain at the surface with only the sample container and a radio beacon needed on the ascent stage. The beacon and power system would be designed to survive (although not operate at) temperatures that are expected to be reached during the ascent through the Venus atmosphere. Phase changing material will be used to moderate the temperature growth.

IV Discussion: These two aerobot based Venus sample return concepts involve a number of complex trades which are being investigated within the context of the VSR study. Although the VGA approach is conceptually simpler it places greater demands on survivability technology. In the VMA approach, complex systems always remain in the relatively benign environment of the upper atmosphere. A key issues is the time involved to achieve rendezvous of aerobots within the atmosphere. We expect to report the results of FORESIGHT modeling of these key features of the architecture.

References: 1. *Venus Sample Return Concepts* by Ross Jones, Kerry T. Nock and Jacques Blamont, JPL Internal Document 1985
2 Venus Geoscience Aerobot Study, by Kerry T. Nock et al. , JPL, July 1997